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FROM: Jay Peters
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Subject: Evaluation of Health and Environmental Effects: Synthetic Turf

The purpose of this memorandum is to provide a summary of recently published studies and reports that evaluate the safety (health and environmental risks) of using synthetic turf athletic fields, with focus on chemicals contained in or associated with synthetic turf and association of synthetic turf with "Heat Islands".

There are approximately 13,000 synthetic turf athletic fields in the United States and more than 1,200 are being added each year. Similarly, the European Chemicals Agency (ECHA) estimates that there are 13,000 large synthetic turf fields in the European Union. There are no state or federal laws that prohibit installation of synthetic turf fields.

A synthetic turf field consists of three main components, including turf blades (the portion of the system that mimics grass blades), a backing material that holds the turf blades in place (similar in concept to backing material that holds household carpet together), and an infill material. The purpose of the infill material is to keep the grass blades standing "up", provide cushioning for the system, and provide appropriate foot to surface interaction (e.g., traction) as well as feeling underfoot (e.g., soft versus firm). Turf blades and backing material are made from polyethylene / and/or polypropylene (plastic family). There are several materials that are used as infill, but a common infill material and the one that is proposed for use at the Buckingham, Brown & Nichols (BB&N) new athletic facility is a mixture of sand and encapsulated crumb rubber; this is the same infill material that BB&N has installed at their turf field at the Upper School – Franke Field.

Crumb rubber, also referred to as recycled crumb rubber, consists of small rubber fragments (between 0.25 and 4 millimeters in diameter) that are created by recycling tires. There has been a lot of focus on crumb rubber as an infill material, primarily due to allegations in 2014 that exposure to crumb rubber is associated with higher rates of cancer. However, evaluation of those allegations by the Washington

Department of Public Health as well as researchers (e.g., Bleyer et al., 2018) determined that there is no link between use of synthetic turf fields with crumb rubber infill and increased incidence of cancer. ***In addition, over 100 scientific, peer-reviewed, published studies have been performed worldwide evaluating the potential health risks associated with using crumb rubber. We are not aware of any peer-reviewed scientific studies which draw an association between adverse health effects and use of crumb rubber.*** Based on the body of evidence, the following state, national and international agencies, governing bodies, and academic institutions have concluded that the use of crumb rubber in athletic fields does not pose a significant human health risk, including (among others) the following:

- Dutch National Institute for Public Health and Environment
- Norwegian Institute of Public Health
- EU - European Chemical Agency (ECHA)
- Connecticut Department of Public Health
- New York City Department of Health
- New York State Department of Health
- The Washington State Department of Health and researchers from the University of Washington School of Public Health

In addition, in 2015 ***the Massachusetts Department of Public Health (DPH) evaluated health concerns related to the use of crumb rubber infill material for artificial turf fields in Medway, Massachusetts, and concluded that "the scientific literature continues to suggest that exposure opportunities to artificial turf fields are not generally expected to result in health effects".*** A communication documenting the MA DPH evaluation is provided as Attachment 1.

Evaluation of Chemicals in Synthetic Turf

Evaluating health risks of using synthetic turf fields requires resolution of the following questions:

1. Are chemicals present in crumb rubber?
2. What are the concentrations of chemicals present in the crumb rubber?
3. How much of the chemical concentrations can people be exposed to (a term referred to as bioavailability)?
4. How much contact with crumb rubber could occur?
5. Is the combination of bioavailable chemical concentration and contact with crumb rubber at a level that can be considered safe? (Would the possible exposure to chemicals in the crumb rubber pose a health concern?)

Risk assessment is the process of resolving these questions. The US Environmental Protection Agency (USEPA) and the Massachusetts Department of Environmental Protection (MassDEP) have established systematic procedures for evaluating health risks (see for example, USEPA (1989), MassDEP (1995 and 2014)). Those procedures are applied to determine if chemicals present in soil, air, and groundwater are safe (i.e., are associated with insignificant health risks). The same procedures have been applied by various entities, as described below, to evaluate the safety of synthetic turf.

Several recent studies have reported on the chemical composition of crumb rubber (e.g., Perkins, et al. (2019); TURI (2020); Celeiro et al (2018; 2021a; 2021b); Gomes et al (2021)). These studies highlight the presence of chemicals that may be contained in crumb rubber, including substances known or suspected of causing cancer in humans, including certain polyaromatic hydrocarbons (PAHs) such as benzo(a)pyrene and certain volatile organic compounds (VOCs) such as benzene.

Understanding the chemical composition of crumb rubber is an important step in evaluating whether the material could pose a potential health concern (Step 1). To help resolve whether the chemicals in synthetic turf are safe, we have reviewed various studies and reports that have evaluated Steps 2 through 5 above. The following provides a summary of recent studies that address this.

- Pavilonis et al. (2014). This research group collected 8 samples of crumb rubber infill material and 8 samples of synthetic turf fibers from various manufacturers as 'new' (i.e., not yet placed on fields) and 'used' (i.e., in-place in 7 synthetic turf playing fields in New Jersey). Samples were subjected to extractions using simulated gastric fluids and simulated sweat and were analyzed for metals and semi-volatile organic compounds (SVOCs). SVOCs and metals were not detected in the fluid extracts from the 'new' samples, whereas some metals were detected in the fluid extracts from samples collected from playing fields. Health risks were estimated by assuming athletes ages six through adulthood used the fields 3 hours per day, 130 days per year, and were exposed to the metals measured in the fluid extracts by incidentally ingesting crumb rubber, breathing in crumb rubber particles, and having crumb rubber particles stick to their skin. ***The researchers concluded that health risks associated with use of synthetic turf fields with crumb rubber infill were orders of magnitude below regulatory levels used to define safety thresholds.***

- Peterson et al. (2018). This research group applied the systematic procedures for risk assessment as cited above using all available study data as of 2017 that reported chemical concentrations in crumb rubber and in air samples collected near synthetic turf fields (37 crumb rubber studies with 103 samples and 139 chemicals evaluated; 9 air studies with 93 samples and 213 chemicals evaluated). Health risks were evaluated by assuming that athletes (ages 6 to 18 years) and young children and adults as spectators contact crumb rubber by accidentally ingesting it, getting it stuck on their skin, and breathing air above the fields (representing air quality that could be affected by the synthetic turf field), 4 days per week for 8 months of the year (139 days per year). To provide a comparison of health risks between use of synthetic turf fields with crumb rubber infill and natural turf fields, the same exposure assumptions were used to evaluate health risks associated with background concentrations of metals and PAHs in soil.

  The results of the study showed that cancer risks for use of synthetic fields were below USEPA's de minimis risk level of $1x10^{-6}$ and MassDEP's risk threshold of $1x10^{-5}$, and that risks for health effects other than cancer were below the EPA and MassDEP threshold value of 1. ***Furthermore, the evaluation showed that risks estimated for use of synthetic turf fields are lower than risks estimated for natural turf fields which contain ambient background levels of metals and PAHs in the soil.*** The authors concluded that the evaluation demonstrated that use of synthetic turf fields containing recycled crumb rubber infill would not result in unacceptable health risks to children or adults under USEPA's risk assessment guidelines.

- USEPA (2019). USEPA collected crumb rubber from 9 tire recycling facilities, 15 indoor turf fields and 25 outdoor turf fields from throughout United States and analyzed the samples SVOCs, metals, and microbes. The study also measured the bioavailable fraction of metals in the samples and the emissions of VOCs at both 77- and 140-degrees F. Key findings from the study are:
  - Metals and SVOC concentrations were similar to those reported in other studies that examined the chemical content of crumb rubber.
  - Emissions of VOCs were generally not detectable at 77F. Emissions of some VOCs increased slightly for some VOCs at 140F. Nevertheless, even at 140F, emissions were very low.
  - Approximately 3% of the metals concentrations were estimated to be bioavailable if the crumb rubber is ingested, and less than 1% were estimated to be bioavailable if the crumb rubber sticks to skin and the metals transfer from the rubber through the skin.
  - The type and number of bacteria in samples of crumb rubber were similar to those present in environments where synthetic turf is not present. The reported cited literature indicating that crumb rubber infill harbors fewer bacteria than natural turf.

The study completed by EPA helps address Steps 1 through 3 above. EPA has not yet used the results of its investigation to evaluate health risks (Steps 4 and 5 above). However, they conclude that "these findings support the premise that while many chemicals are present in the recycled crumb rubber, exposure may be limited based on what is released into air or biological fluids".

We further evaluated the analytical data for crumb rubber that was reported on by EPA (2019) to help provide context for the results in terms of crumb rubber safety. Specifically, we compared the 90th percentile concentrations of metals and SVOCs, as reported by USEPA in Tables 4-34 and 4-36 of their report, to screening levels published by MassDEP and USEPA. Specifically, the MassDEP screening levels are the Massachusetts Contingency Plan (MCP) S-1/GW-3 soil standards, which would be applicable to evaluation of soil in a natural turf field located where the BB&N field is proposed, and the USEPA Regional Screening Levels (RSLs) for residential soil for substances which are not published in the MCP. The 90th percentile concentration was used because it is a statistic that is consistent with the value that MassDEP recommends for assessing exposures to soil during activities such as recreational uses of a playing field (MassDEP, 2014).

Tire Crumb Rubber Sampling Location	Chemical	90th Percentile (mg/kg)	Screening Level (mg/kg)	
Recycling Plants	Arsenic	0.45	20	a
Recycling Plants	Cadmium	0.73	70	a
Recycling Plants	Chromium	2.4	100	a
Recycling Plants	Cobalt	280	23	b
Recycling Plants	Lead	22	200	a
Recycling Plants	Zinc	21000	1000	a
Synthetic Turf Fields	Arsenic	0.60	20	a
Synthetic Turf Fields	Cadmium	1.7	70	a
Synthetic Turf Fields	Chromium	2.7	100	a
Synthetic Turf Fields	Cobalt	220	23	b
Synthetic Turf Fields	Lead	55	200	a
Synthetic Turf Fields	Zinc	19000	1000	a

a - MassDEP MCP Standard (S-1/GW-3) (310 CMR 40.0975(6)(a)
b - USEPA Regional Screening Level for residential soil (hazard index = 1; cancer risk = 1E-06)
(www.epa.gov/risk/regional-screening-levels-rsls-generic-tables)

Tire Crumb Rubber Sampling Location	Chemical[b]	90th Percentile (mg/kg)	Screening Level (mg/kg)	
Recycling Plants	Phenanthrene	5.8	500	a
Recycling Plants	Fluoranthene	8.6	1000	a
Recycling Plants	Pyrene	22	1000	a
Recycling Plants	Benzo[a]pyrene	1.4	2	a
Recycling Plants	Benzo[ghi]perylene	2.0	1000	a
Recycling Plants	Benzothiazole	100	NA	
Recycling Plants	Dibutyl phthalate	1.5	6300	b
Recycling Plants	Bis(2-ethylhexyl) phthalate	34	90	a
Recycling Plants	Aniline	6.3	95	a
Recycling Plants	4-tert-octylphenol	40	NA	
Recycling Plants	n-Hexadecane	6.5	NA	
Synthetic Turf Fields	Phenanthrene	6.1	500	a
Synthetic Turf Fields	Fluoranthene	8.1	1000	a
Synthetic Turf Fields	Pyrene	21	1000	a
Synthetic Turf Fields	Benzo[a]pyrene	1.4	2	a
Synthetic Turf Fields	Benzo[ghi]perylene	2.0	1000	a
Synthetic Turf Fields	Benzothiazole	31	NA	
Synthetic Turf Fields	Dibutyl phthalate	3.5	6300	b
Synthetic Turf Fields	Bis(2-ethylhexyl) phthalate	100	90	a
Synthetic Turf Fields	Aniline	1.2	95	b
Synthetic Turf Fields	4-tert-octylphenol	27	NA	
Synthetic Turf Fields	n-Hexadecane	2.6	NA	

a - MassDEP MCP Standard (S-1/GW-3) (310 CMR 40.0975(6)(a)
b - USEPA Regional Screening Level for residential soil (hazard index = 1; cancer risk = 1E-06)
(www.epa.gov/risk/regional-screening-levels-rsls-generic-tables)
NA - Not Available

As indicated, the concentrations of all chemicals except bis(2-ethylhexyl)phthalate, cobalt and zinc are below their respective screening levels. The screening level for bis(2-ethylhexyl)phthalate is based on a de minimis cancer risk level. The 90th percentile concentration of 100 mg/kg is only 10% higher than the screening level, indicating that the concentration of bis(2-ethylhexyl)phthalate is still within a range this is considered to be safe by MassDEP. The screening levels for cobalt and zinc are based on the assumption that the metals are 100% bioavailable. If the 90th percentile concentrations were adjusted for the bioavailability of the metals in the crumb rubber, as reported by USEPA in Table 102 of their report, the value for cobalt would be 3.4 mg/kg (at 1.2% for maximum bioaccessibility) and zinc would be 475 mg/kg (at 2.5% maximum bioaccessibility), which are both below the screening levels.

Based on this evaluation, the chemicals in crumb rubber as reported by USEPA, would not pose significant health risks and therefore would be considered safe for use as infill in synthetic turf fields.

- Schneider et al. (2020). This paper reports on the outcome of the European Risk Assessment Study on Synthetic Turf Infill. It uses measurements of chemicals detected in crumb rubber infill to estimate health risks to bystanders (young children) and athletes ages 4 to 35 years who were assumed to contact infill material. More specifically, the study assessed substances that were A) detected in rubber infill material, B) could volatilize from the rubber infill material, or C) could be extracted at sufficient quantity into simulated gastric or sweat fluid or simply had particularly hazardous properties. Using the bioavailable chemical concentrations, the evaluation characterized risks for the bystanders and athletes assumed to contact infill material 1.5 to 4 hours per day, 112 to 240 days per year. ***The study concluded that estimated risks for use of synthetic turf fields with crumb rubber infill were below guidelines used by both the European Union and the USEPA.***

- Pronk, eta al. (2020). Similar to testing reported on by Schneider et al. (2020) and USEPA (2019), Pronk et al. collected rubber infill samples from 100 pitches in the Netherlands (6 samples per pitch resulting in 600 total samples of rubber infill material) and analyzed them for SVOCs and metals. Samples were also subjected to extraction by simulated gastric and sweat fluids, and VOC emissions were measured in samples incubated at 140F. Using the bioavailable chemical concentrations, the evaluation characterized risks for study populations similar to those evaluated by Schneider et al. (2020). ***The study concluded that chemical concentrations in crumb rubber infill complied with concentration limits set for mixtures of substances in Europe, and that health risks were below regulatory guidelines.***

- Tetra Tech (2021). Tetra Tech evaluated the chemical composition of a synthetic turf system proposed to be installed as a component of the Martha's Vineyard Regional High School Athletic Fields Project. The evaluation included chemical analyses of each turf system component (turf carpet, shock pad, glue and bonding agents, and infill) for SVOCs, metals, and per-and poly-fluoroalkyl substances (PFAS). Testing was performed to evaluate both total and leachable concentrations. The analytical results were used in a risk assessment to evaluate possible pathways for migration of chemicals to the environment, potential exposure to human and environmental receptors, and possible health and environmental risks. The risk assessment was completed by comparing detected concentrations to standards and screening levels that are protective for exposure to soil in a residential yard setting (i.e., high frequency contact by toddlers, young children, adolescents and adults), and protective for migration to groundwater that is used as drinking water.

Based on the results of the risk assessment Tetra Tech concluded that:

- Concentrations of metals were similar to or less than those that naturally occur in soil and were below standards and screening levels.
- Most SVOCs were not detected, and those that were detected were below standards and screening levels.
- None of the six PFAS compounds regulated by MassDEP were detected. Two PFAS compounds (PFPeA and 6:2FTS) that are not regulated by MassDEP were in synthetic turf system samples detected at low (estimated) concentrations that were also below available standards published for other PFAS compounds.
- None of the compounds analyzed were detected at concentrations that would pose a concern for leaching to groundwater.

The Tetra Tech report also evaluated PFAS using a procedure which evaluates the potential for transformation of a certain class of PFAS compounds (known as precursors) into other PFAS compounds, to mimic conditions that could hypothetically occur under some environmental conditions. The results of the procedure indicate that two additional PFAS compounds (PFHpA) and PFBA could be generated through transformation of PFAS precursor compounds. Although these two PFAS compounds are not regulated by MassDEP, the concentrations yielded by the procedure were less than MassDEP soil standards for regulated PFAS compounds.

A significant aspect of the Tetra Tech study is that it evaluated each of synthetic turf system components for chemicals that have historically been evaluated in crumb rubber infill (e.g., metals and PAHs), as well as PFAS. PFAS is not a chemical that is added to synthetic turf components, nor is it used to manufacture tires which are recycled to create crumb rubber. Therefore, there is no reason to suspect that it would be present in synthetic turf carpeting or crumb rubber infill. However, questions concerning PFAS in synthetic turf were raised in a 2019 article that was published in the Boston Globe and The Intercept. A critical review of the findings cited in those articles is provided in Attachment 2. In summary, the findings reported in the articles indicate that PFAS compounds were detected but at concentrations that are within the range of background concentrations found in soil. Subsequent to the evaluation provided in Attachment 2, MassDEP published PFAS standards for soil. A review of the PFAS concentrations reported in the articles indicates that they are below MassDEP's PFAS standards for soil, indicating that the PFAS reported in the articles would not pose harm to people or the environment.

The testing completed by Tetra Tech, demonstrated that none of the PFAS compounds regulated by the MassDEP were detected in any of the synthetic turf systems components, and that PFAS compounds would not leach from any of the synthetic turf system components at

levels that would be a concern for groundwater or surface water. As with other studies, the Tetra Tech study also documented that metals and PAHs in synthetic turf are not a concern for harm to people or the environment.

We note that the infill material tested by Tetra Tech is not a crumb rubber infill material (i.e., it is a wood fiber material called BrockFill). Therefore, the analytical results and conclusions of the Tetra Tech report as they relate to the infill material are not necessarily applicable to the infill material proposed for the BB&N athletic field project. However, since the results of the Tetra Tech report indicate that the synthetic turf system would not pose any significant risks to human health or the environment, it can be concluded that turf carpeting and bonding agents alone would not pose any significant risks.

In summary, the presence of chemicals in synthetic turf materials have been well documented. However, numerous studies and reports have also demonstrated that the chemicals that are in the synthetic turf cannot come out of the materials at concentrations that would harm people or the environment. Consequently, synthetic turf systems, including turf blades and crumb rubber infill, are safe for contact by people and will not harm groundwater or surface water.

Evaluation of "Heat Island" and Synthetic Turf

A Heat Island is an area where the temperature is higher than in the surrounding area. Heat Islands are caused by reduced natural landscape in urban areas, the properties of urban materials (pavement, roofing, aggregate-based building materials), urban geometry (dimensions and spacing of buildings which can trap heat), heat generated by human activities (e.g., automobiles, air conditioning), and weather and geography. In particular, the combination of urban materials and urban geometry can create large thermal masses that cannot easily release heat. According to the USEPA[1], Heat Islands often build throughout the day and become more pronounced at night due to the slow release of heat from urban materials.

The surfaces of synthetic turf fields get warmer than the surfaces of natural turf fields. However, the differences in temperatures vary depending on weather conditions (e.g., sunny versus cloudy) and time of day. Several studies have examined the differences in heating between synthetic turf fields and natural turf fields. A comprehensive study by Jim et al. (2017) indicates that:

- On sunny days, surface temperatures of synthetic turf fields can be 30 to 40 degrees C higher than surfaces of natural turf fields. On cloudy days (defined as days when cloud cover reduced solar radiation to approximately one-half that of sunny days) surface temperatures of synthetic turf fields may be approximately 20 degrees C higher than natural turf fields, and on overcast days (defined as days when cloud cover reduced solar radiation to approximately one-quarter that of sunny days) there is essentially no difference in field surface temperatures.

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[1] [1] www.epa.gov/heatislands/learn-about-heat-islands

- Despite substantial surface temperature differences between synthetic and natural turf fields on sunny days, there is only a few degrees (centigrade) difference in air temperature between synthetic turf and natural turf fields at 20 inches and 40 inches above the playing field surface, and essentially no difference in air temperature at 60 inches above the field surfaces. This difference becomes smaller as daytime heating increases, with 20- and 40-inch air temperatures above synthetic turf nearly equaling those above natural turf during the afternoon hours. On cloudy and overcast days there is essentially no difference in air temperatures between synthetic turf and natural turf fields at 20- and 40-inches above the playing field surfaces.
- Synthetic turf surfaces and the air above synthetic turf fields heats and cools more rapidly than those associated with natural turf.
- The solar radiation released by natural and synthetic turf fields during nighttime is the same, meaning that that synthetic turf does not 'hold heat' and release it after sunset. This observation reflects that fact that synthetic turf has a poor heat storage capacity, which is reflected in the rapid changes in surface temperature profiles of synthetic turf as compared to natural turf, and the observation that synthetic turf surfaces return to the same temperature as natural turf surfaces when solar radiation is reduced (e.g., late afternoon/evening on sunny days and the duration of the day on overcast days).

The location of the new BB&N athletic facility is presently occupied by a paved (asphalt) parking lot. Unlike synthetic turf, asphalt continues to release heat once daytime heating is discontinued. In fact, a study by Yang et al. (2020) demonstrated that asphalt surfaces that are heated by the sun (i.e., 'sunny day' conditions) continue to release heat for several hours after heating is discontinued (i.e., after sunset). Consequently, replacing the existing asphalt parking lot with synthetic turf fields will improve environmental conditions by <u>decreasing</u> the existing Heat Island effects contributed by the paved parking lot.

Collectively, this information suggests that, while synthetic turf field <u>surfaces</u> get warmer than natural turf field surfaces, air temperatures above synthetic turf surfaces warm only marginally more than those above natural turf field surfaces, and that synthetic field surfaces do not retain heat once day-time heating is discontinued. These differences are substantially minimized on cloudy days and do not exist on overcast days. Moreover, the information suggests that replacing the existing asphalt parking lot with a synthetic turf field will improve environmental conditions by reducing paved surfaces that continue to emit heat after sunset. In that respect, synthetic turf fields are different than urban systems (aggregate buildings, roof tops, and pavement) which are associated with contributing to Heat Island effects which by the nature of those materials continue to release heat well into the nighttime hours. Given that the BB&N athletic field will not be surrounded by buildings made of urban materials, effects associated with urban geometry and lack of air movement will not be a factor. Finally, consider that the athletic field proposed by BB&N is replacing an asphalt parking lot. It is therefore not removing any pre-existing green space and thus not reducing natural landscape that already exists.

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Attachment 1
Massachusetts Department of Public Health Evaluation of Health Concerns Related to Synthetic Turf

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March 23, 2015

Stephanie Bacon, Health Agent
Office of Board of Health
155 Village Street
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Dear Ms. Bacon:

Thank you for your letter of February 24, 2015, in which you requested that the Massachusetts Department of Public Health, Bureau of Environmental Health (MDPH/BEH), evaluate health concerns related to the use of crumb rubber infill material for artificial turf fields in Medway, Massachusetts. As you are likely aware, our office had previously evaluated this issue in a series of letters to the Town of Needham Board of Health in 2008, 2011, and 2013.

In response, MDPH/BEH staff have evaluated more recent information on potential exposure opportunities to artificial turf components, including crumb rubber infill, and evaluated health concerns, including cancer, in relation to exposure to such turf. Recent media reports on soccer players, particularly goalies that have played on artificial turf, and the incidence of some cancers have been expressed. These reports raised concerns about the possible association between playing on crumb rubber fields and the development of cancers, notably, non-Hodgkin's lymphoma, Hodgkin Lymphoma, and osteosarcoma. We also evaluated information you provided on the content of the specific products used in Medway. Our review is summarized below.

<u>Updated Literature Review</u>

Our previous evaluations noted that crumb rubber infill has been found to contain chemicals, including polycyclic aromatic hydrocarbons (PAHs), volatile organic compounds (VOCs), and metals. We further stated that although these chemicals are in the material itself, information available at that time did not suggest significant exposure opportunities to the chemicals in the materials such that we would expect health effects. We noted that the most relevant study on this topic at the time was a study conducted by the California Office of Environmental Health Hazard Assessment (CA OEHHA).

Since that time, the CA OEHHA conducted additional evaluations of chemical concentrations in air above crumb rubber turf fields under active use (CA OEHHA 2010). Air samples were taken above fields and analyzed for VOCs and metals. Results suggested that adverse health effects were unlikely to occur from inhalation of VOCs or metals in particulates above these fields. To assess the potential for skin infections due to bacteria or to skin abrasions on these fields, tests for bacterial contamination were performed and the frequency of skin abrasions was assessed. Researchers found fewer bacteria detected on the artificial turf compared to natural turf, suggesting that the risk of infection to athletes using these fields was actually lower. However, more skin abrasions were observed in athletes using artificial turf fields than natural turf fields, and the study authors made various recommendations to help prevent skin abrasions (e.g., protective equipment or clothing) and prompt treatment of skin abrasions.

In another study, the state of Connecticut conducted air sampling at four outdoor artificial turf fields with crumb rubber infills (most relevant to Medway) under summer conditions (Simcox et al. 2011). Air measurements were taken using stationary air sampling monitoring devices as well as personal samplers (placed on people using the fields). They concluded that exposure opportunities to turf contaminants were not associated with elevated health risks and suggested that their findings were consistent with other studies available at the time. A letter prepared by the Connecticut Department of Public Health reiterates these conclusions (CTDPH 2015).

A 2014 study by researchers at the Rutgers Robert Wood Johnson Medical School in New Jersey evaluated opportunities for exposures to PAHs, semivolatile organic compounds (SVOCs), and heavy metals from exposures to artificial turf fibers and crumb rubber infills by measuring these constituents in simulated body fluids (digestive fluids, lung fluids, sweat) that represented different routes of exposure (ingestion, inhalation, dermal). This bioaccessibility study aimed to provide a better measure of the actual amount of these contaminants that might be absorbed into the body after exposure. The researchers found that PAHs were routinely below the limit of detection and SVOCs that have environmental regulatory limits to use for comparison were identified at levels too low to quantify. Some metals were detected but at concentrations at which health risks were low, with the exception of lead from the field sample collected. That sample indicated lead at levels in the simulated digestive fluids that the authors reported could result in blood lead levels above the current U.S. Centers for Disease Control and Prevention (CDC) reference value for blood lead in children (5 ug/dL). It should be noted that the lead concentration of the materials used in this study included a sample of turf fiber with a lead concentration of 4,400 mg/kg. This level contrasts with information on the Medway artificial turf components, which reportedly either contained lead at 39 mg/kg (crumb rubber infill) or had no lead (turf fibers) (see discussion later in this letter). Based on the lead result from this one field sample, the authors suggested that components of artificial turf fields should be certified for low or no lead content prior to use. Overall, however, the authors concluded that opportunities for exposure to constituents in these fluids presented very low risk among all populations that would use artificial turf fields (Pavilonis et al. 2014).

A study conducted in 2010 in the Netherlands assessed the exposure of soccer players to PAHs after playing sports on a rubber crumb field. Urine testing in participants indicated that uptake of PAHs by the participants following exposure to artificial turf with rubber crumb infill was minimal. If there is any exposure, the authors reported, uptake is minimal and within the normal range of uptake of PAHs from environmental sources and/or diet observed in healthy individuals (van Rooij and Jongeneelen 2010).

It is probably worthwhile to also note that MDPH/BEH reviewed testing data for artificial turf for the Town of Needham, as reported in our letters of 2011 and 2013 to the Needham Board of Health. The Town of Needham contracted with an environmental testing firm to conduct environmental tests including, air measurements of volatile organic compounds taken in the laboratory and heavy metals (arsenic, cadmium, chromium, lead, mercury, selenium, zinc) content of crumb rubber materials. Our review and conclusions for that testing, did not indicate exposures of health concern.

Material in Medway

MDPH/BEH reviewed available information provided by the Medway Board of Health regarding the specific materials used in the Medway fields. These included the APT Gridiron turf system and Liberty Tire Recycling 10+20 BM Rubber Crumb Brantford, ON. Among the materials provided for these products were statements or test results for various constituents in these products.

APT submitted a written statement dated October 29, 2014, that reported that the APT Gridiron turf systems (essentially the grass fibers of the artificial turf) are manufactured and installed without the use of any lead or heavy metals. They reported that this included all materials used for the turf fibers and backings. No other documentation about this product, including any testing results, was provided to support this statement.

With respect to the 10+20 BM Crumb Rubber infill product, laboratory testing results were provided for this product, although it is not clear whether the testing was for the materials specifically used in turf applied in Medway. Testing was conducted for metals content as well as emissions of volatile organic compounds (VOCs). It appears that testing included the following: (1) testing for VOCs emitted into a confined air space in the laboratory after heating the product to 73 degrees F; and (2) content testing for eight heavy metals, including lead. The laboratory compared results to criteria established by the Greenguard certification program, part of Underwriters Laboratory, that uses among its criteria for certification health-based levels derived by the CA OEHHA.

Testing results for metals content of the product indicated a lead concentration of 39 mg/kg, which is less than the current Consumer Product Safety Improvement Act (CPSIA) limit of 100 mg/kg for lead in children's products (Ulirsch et al. 2010). No other metals were detected.

Test results measuring emissions off-gassing from heated material were provided in measurements that cannot be compared to any health-based standards or guidelines and thus, MDPH/BEH did not further evaluate this information. Typically, when certain products raise health concerns, health agencies review Material Safety Data Sheets (MSDS). An MSDS provides information on health risks associated with use of the product. An industry group, Synthetic Turf Council, provides a sample template MSDS for crumb rubber infill material (Synthetic Turf Council 2014). Although this sample MSDS is not specific to any particular product, it appears to be applicable to crumb rubber infill in general. In the section under "Hazardous Ingredients," the MSDS notes that the product can contain fine fibers that may cause irritation symptoms (e.g., itching, irritation of mucous membranes, eye irritation). The MSDS notes that the crumb rubber material is generally thought to be a nuisance dust.

Concerns About Cancer Among Soccer Players

As noted earlier in this letter, some recent news reports suggested that the incidence of cancers among soccer players, particularly goaltenders exposed to artificial turf, might be atypical. These reports included many cancer types, but some focused specifically on NHL, Hodgkin Lymphoma, and osteosarcoma in three individuals. We thought it would be helpful to provide additional information on cancers in general and known risk factors for NHL, Hodgkin Lymphoma, and osteosarcoma.

Cancer in General

Understanding that cancer is not one disease, but a group of diseases, is very important. Research has shown that there are more than 100 different types of cancer, each with separate causes, risk factors, characteristics and patterns of survival. A risk factor is anything that increases a person's chance of developing cancer and can include hereditary conditions, medical conditions or treatments, infections, lifestyle factors, or environmental exposures. Although risk factors can influence the development of cancer, most do not directly cause cancer. An individual's risk for developing cancer may change over time due to many factors and it is likely that multiple risk factors influence the development of most cancers. In addition, an individual's risk may depend on a complex interaction between their genetic make-up and exposure to environmental agents, including infectious agents and/or chemicals. This may explain why some individuals have a fairly low risk of developing a particular type of cancer as a result of an environmental exposure, while others are more vulnerable.

Cancers in general have long latency or development periods that can range from 10 to 30 years in adults, particularly for solid tumors. In some cases, the latency period may be more than 40 to 50 years. It is important to note, however, that latency periods for children and adolescents are significantly shorter than for adults.

Hodgkin Lymphoma

Hodgkin Lymphoma is most common in young adults between the ages of 15 and 40, especially in individuals in their 20s. Among adolescents, it is the most common type of cancer.

Hodgkin Lymphoma occurs specifically in a type of B lymphocyte (or white blood cell) called the Reed-Sternberg cell while other lymphomas (non-Hodgkin's types) occur in different cells.

Established risk factors for Hodgkin Lymphoma include: exposure to the Epstein-Barr virus (EBV); a previous diagnosis of mononucleosis (mono is caused by the EBV); family history; and certain hereditary conditions (such as ataxia telangiectasia) associated with a weakened immune system. The Epstein-Barr virus is very prevalent in the general population. Even though most of us have been exposed to the virus (which remains latent in our bodies), most people do not develop mononucleosis or Hodgkin Lymphoma. EBV is thought to account for about 20% or 25% of the diagnoses of classical Hodgkin's in the US.

Higher socioeconomic status is also a possible risk factor. This is thought to be due to delayed infectious exposures in childhood.

Occupational exposures as risk factors have been studied extensively and none have emerged as established risk factors. Likewise, there is very little evidence linking the risk of Hodgkin Lymphoma to an environmental exposure, other than the EBV.

Non-Hodgkin Lymphoma (NHL)

NHL refers to a diverse group of cancers that are characterized by an increase in malignant cells of the immune system. Each subtype of NHL may have different risk factors associated with its development. The specific cause of NHL in most individuals is unknown.

Although some types of NHL are among the more common childhood cancers, more than 95% of diagnoses occur in adults. Incidence generally increases with age, and most diagnoses occur in people in their 60s or older.

Established risk factors for NHL include a weakened immune system, associated with various medical conditions, and exposure to various viruses. An increased risk is faced by individuals taking immunosuppressant drugs following organ transplants; individuals with autoimmune disorders, such as rheumatoid arthritis and lupus; and individuals who have taken certain chemotherapy drugs for other cancers. Several viruses have been shown to play a role in the development of NHL, including the human immunodeficiency virus (HIV), the human T-cell leukemia/lymphoma virus (HTLV-1), and the Epstein-Barr virus.

Exposure to high-dose radiation (for example, by survivors of atomic bombs and nuclear reactor accidents and possibly by patients who have received radiation therapy for a previous cancer) may pose an increased risk. Some studies have also suggested that exposure to chemicals such as benzene and certain herbicides and insecticides may be linked with an increased risk of NHL. Smoking has been associated in some studies with certain types of NHL.

Osteosarcoma

Osteosarcoma is a type of malignant bone cancer which accounts for about 2% of childhood cancers in the United States. It is the most common type of cancer that develops in bone and comprises about 66% of malignant bone tumors in children in Massachusetts. Most osteosarcomas occur in children and young adults between the ages of 10 and 30. Teenagers comprise the most commonly affected age group and are at the highest risk during their growth spurt. However, osteosarcoma can occur in people of any age, with about 10% of all osteosarcomas occurring in people over the age of 60.

Established risk factors for osteosarcoma include certain inherited syndromes (such as retinoblastoma, the Li-Fraumeni syndrome, and others) and certain bone diseases (such as Paget disease of the bone and hereditary multiple osteochondromas). Individuals with these syndromes and bone diseases have an increased risk of developing osteosarcoma. People who have received radiation treatment for a previous cancer may have a higher risk of later developing osteosarcoma in the area that was treated. Being treated at a younger age and with higher doses of radiation both increase the risk. Because the risk of osteosarcoma is highest between the ages of 10 and 30, especially during the teenage growth spurt, experts believe that there may be a link between rapid bone growth and the risk of a bone tumor. Children with osteosarcoma are often tall for their age, which supports the link with rapid bone growth. Other than radiation, there are no known lifestyle or environmental risk factors associated with osteosarcoma. Asides from these risk factors, the causes of most osteosarcomas are unknown.

Summary

In summary, the scientific literature continues to suggest that exposure opportunities to artificial turf fields are not generally expected to result in health effects. Testing results on the crumb rubber infill indicated lead content less than CPSIA statutory limits established for children's products. For the turf fibers, APT provided a statement that this material did not have lead used in its manufacture, but no additional documentation was provided.

With respect to cancer concerns reported in media stories, it is important to note that the reports of cancers were of a wide variety of different types, each with its own set of risk factors. In addition, our staff reviewed cancer incidence data for the Town of Medway. The Massachusetts Cancer Registry (MCR) is a population-based surveillance system that began collecting information in 1982 on Massachusetts residents diagnosed with cancer in the state. All newly diagnosed cancer cases among Massachusetts residents are required by law to be reported to the MCR within six months of the date of diagnosis (MGL, c.111, s.111B). This information is kept in a confidential database and reviewed for accuracy and completeness.

Available information on the occurrence of cancers in children living in Medway indicates no diagnoses of Hodgkin Lymphoma, NHL, or osteosarcoma have been reported to the MCR in a search of their files from 2006 to the present. Although it is possible that a very recent diagnosis may not yet have been reported to the MCR, the fact that there are no reports of such cancers is reassuring.

Although available resources cannot support MDPH conducting environmental testing of this material, we would be happy to assist the Town of Medway in developing a sampling and analysis plan as well as provide technical support in interpreting results, similar to the assistance that we provided to the Town of Needham.

As we stated in our letters to Needham officials, while available information does not indicate exposure opportunities of health concern, MDPH/BEH continues to recommend common sense ways to minimize any potential exposure to chemicals that may be contained in synthetic turf fields made of crumb rubber. MDPH/BEH suggests washing hands after playing on the field and before eating, particularly for younger children with frequent hand-to-mouth activity, and taking off shoes before entering the house to prevent tracking in any crumb rubber particles. Also, there are studies that indicate heat levels on artificial turf fields may rise as outdoor temperatures increase (New York State 2009). Thus, for protection of the players, MDPH/BEH recommends increasing hydration, taking frequent breaks, and watering down the field to cool it on hot days to prevent the potential for burns or heat stress. Finally, based on recent work in California, MDPH/BEH recommends that steps be taken to minimize the potential for skin abrasions (e.g., protective equipment) and that skin abrasions be treated promptly to prevent potential infections.

We hope this information is helpful to you and Medway residents. If you have any questions, please feel free to contact us at 617-624-5757.

Sincerely,

Suzanne K. Condon, Associate Commissioner
Director, Bureau of Environmental Health

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Attachment 2
Evaluation of PFAS in Synthetic Turf as Reported by Boston Globe and The Intercept

TO: Patrick Maguire; Synthetic Turf Stakeholders

FROM: Stephen R. Clough, Ph.D., DABT
Senior Environmental Toxicologist

DATE: 25 October 2019

SUBJECT: Low Levels of PFAS Detected in Samples of Discarded Turf

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Recent news articles from both the **Boston Globe** (Toxic chemicals are found in blades of artificial turf) and **The Intercept** (Toxic PFAS chemicals found in artificial turf) have reported analytical laboratory results of synthetic turf sampled for the presence of perfluorinated alkyl substances (PFAS). This information, however, is of a preliminary nature as the results having not been peer-reviewed nor have the concentrations been put into context (e.g. compared to ambient levels reported for soils in unimpacted locations).

In lieu of this information, suppliers of synthetic turf have been contacted to determine if PFAS are utilized in the manufacture of their products (PFAS is not present in recycled tires and therefore crumb rubber). Vendors and manufacturers of turf products have, in the past, stipulated that all of their products meet California Prop 65 and European REACH standards of safety. Moving forward, Activitas Inc. wants to ensure that all products used in the construction of their synthetic turf fields meet the highest levels of quality assurance and safety, which includes minimizing exposure and subsequent risk to any potentially toxic chemicals of concern.

Background. PFAS are a family of highly fluorinated alkyl compounds used in a host of commercial and consumer products to provide durable waterproof coatings. Because of the nonspecific methods used to generate thousands of different types of PFAS, little has been done in terms of understanding their fate and transport. The scientific community is therefore evolving its understanding of PFAS in the environment. PFAS are considered to be contaminants of emerging concern (CECs). CECs are chemicals that have the potential to affect human health or present an environmental risk, and either: (1) do not have regulatory cleanup or health-based standards and/or (2) regulatory standards are evolving due to new science, detection capabilities or exposure pathways. PFAS are "ubiquitous" in the environment because a) they have been used in hundreds of different consumer products (e.g. carpet, waxes, lubricants, nonstick coatings, firefighting foams, leather, etc.) for over 60 years and b) they do not degrade and tend to concentrate in wildlife. Additionally, the carbon-fluorine bond affords detection of most PFAS at infinitesimally low levels, thus allowing observation in all media: air, soil, sediment, groundwater, surface water, animals and humans. Because the amount of peer-reviewed information available on PFAS is voluminous, it is recommended the reader peruse "fact sheets" available in States that are affected by environmental releases (e.g. ITRC PFAS Fact Sheets).

Toxicity research is also evolving, and several large epidemiological studies have "linked" exposure to adverse health effects in humans following long-term drinking water exposure to PFOA and PFOS compounds. The primary exposure route that the USEPA and State regulatory agencies have identified is through consumption of PFAS in contaminated drinking water. Based on research studies and what is known about the chemical composition of PFAS, dermal (skin) exposure to PFAS containing materials is not significant and thus poses a negligible human health risk. Similarly, due to the high water solubility of PFAS and low volatility, these compounds pose a negligible health risk via the inhalation exposure pathway.

Review of Methods. While the preliminary results following the sampling and analysis of discarded turf appears to indicate that PFAS may be present in both the backing and the blades of synthetic turf, a more careful evaluation of the information from the newspaper articles has identified the following issues that may bias an uninformed reader:

- It is well documented at both the State and Federal level that cross-contamination during sampling is a very important issue and, given the ubiquity of PFAS, is a common problem in the field. Technicians need to go through meticulous training to avoid contaminating the sample with materials containing PFAS or fluorine (including gloves, clothing, sampling items, containers, notebooks, makeup, perfumes, etc.). The articles do not mention what precautions were taken in the field, and the results would be suspect if Massachusetts Department of Environmental Protection standard operating procedures were not followed.

- There is no certified method for analyzing PFAS concentrations in materials other than a US EPA method for analyzing PFAS in drinking water. Since the samples were synthetic turf and not drinking water, the methods used for analysis were likely not certified and therefore, the results are questionable. Additionally, the article incorrectly compares apples to oranges, stating "...the swatch of turf from Franklin contained 190 parts per trillion of one of the most common PFAS chemicals, well above federal safety standards for drinking water." The laboratory results from a solid "swatch" would be reported as nanograms per kilogram (ng/kg), but a standard for drinking water would be nanograms per liter (ng/L). Thus the comparison of a PFAS in a bulk sample to a drinking water advisor is misleading.

- The article noted that an additional eight samples were analyzed for total fluorine and assumed that total fluorine is an indication that PFAS is present. Total fluorine, however, is a non-specific method and thus a poor proxy for PFAS. The method can be biased by the presence of many non-PFAS compounds. For example, some anionic surfactants applied to the field drain may contain fluorine. Many consumer products also contain fluorine such as toothpaste, mouthwash and household cleaners. The presence of fluorine, therefore, does not necessarily indicate PFAS compounds are present.

Evaluation of the Analytical Results and Potential Exposure/Risk. If one assumes in good faith that the results are correct, what does a concentration of 190 parts per trillion (0.19 ug/kg) of PFOS in synthetic turf mean? A review paper by Vedagiri and Loso (Remediation Journal, 2019) identified the range of PFOS levels in soil samples taken from "ambient" or "background" locations in 21 States "with no known point source" of PFAS. In other words, samples were taken from rural, uncontaminated areas that were away from urban/suburban impacts. The range of concentrations for PFOS, which was detected in every soil sample taken in North America (N=38), was 0.018 - 2.55 μg/kg (range of PFOA was 0.059 – 1.84 ug/kg). The concentrations in the eastern U.S. are much higher (>0.184 ug/kg). Thus, a concentration of 0.19 ug/kg PFOS in a swatch of used turf falls into this uncontaminated concentration range which would be considered "clean". While synthetic turf is not soil, the fields do receive atmospheric deposition of dust which is recognized as a major PFAS transport mechanism. Moving forward, concentrations in swatches would need to approach 2.5 parts per billion of PFOS (and 1.8 ug/kg PFOA) to raise a concern in terms of categorizing used turf as a potentially hazardous material.

These authors also compared these values to a residential soil Risk Screening Level of 1,260 ug/kg which applies to both PFOS and PFOA. All the background concentrations were well below the safe soil RSL "by two to three orders of magnitude". The concentrations of PFOS in soil cited by ITRC's recent "Fact Sheets" (Table 4-2) that are protective of both human health and underlying groundwater are also much greater than the value of 0.19 ug/kg cited by the recent articles. Based on these comparisons, human health risk is negligible.

Finally, it is noteworthy to mention, based on the conclusions of US EPA's recent Synthetic Turf Research Action Plan, that bioavailability of toxic chemicals (e.g. metals, polycyclic aromatic hydrocarbons) in synthetic turf is very low (≤3%). Thus reporting "total" PFAS that would be bound up in the matrix of the turf backing or plastic blades would overestimate what an athlete would actually be exposed to following contact.

Based on the above information, which addresses analytical uncertainties, concentrations relative to clean background locations, potential exposure, and subsequent human health risk, one may conclude that the discovery and reporting of ultratrace levels of PFAS in used synthetic turf appears to be overstated if not misleading.

Activitas, Inc. will continue to monitor this important issue and strive to keep all synthetic turf products free from any potentially toxic constituents of concern. We will also provide updates on this subject as additional information becomes available.